**Exercise session 1**

**Problem 1 [Cold beer for summer days]**

A small family enterprise Beerbon – beer producer – wants to plan its operations for the coming 4 months. To produce 1 litre of beer the company needs:

* 1 litre of water
* 0.1 kg of malted barley
* 3 g of hops

We assume yeast is not an issue here (there is always enough of free yeast). The cost of producing 1 litre of beer is $0.3. There is scarcity of materials needed to produce beer. The firm cannot store the ingredients but it can store the product (the beer) – it costs $0.5 per 1 litre per 1 month. The company starts with no stocks. It can sell everything it produces (the market is non-satiated), but it must sell at least 500 litres of beer each month. All the data is presented in the table below:

|  |  |  |  |
| --- | --- | --- | --- |
| Month | Available ingredients | Price of ingredients | Price of beer (1l) |
| water (l) | malted barley (kg) | hops (g) | water (l) | malted barley (kg) | hops (g) |
| 1 | 1800 | 200 | 6000 | 0 | 3 | 0.2 | 2 |
| 2 | 2000 | 160 | 6000 | 0 | 4 | 0.3 | 2.5 |
| 3 | 1600 | 200 | 5000 | 0 | 5 | 0.3 | 3.2 |
| 4 | 2000 | 200 | 6000 | 0 | 6 | 0.3 | 3 |

1. Formulate a linear programming problem, define decision variables, a goal function, and constraints.
2. Find a solution using Solver AddIn to MS Excel
3. Suppose it was possible to store malted barley for later use. How much is such possibility (a storage device) worth to the manager of Beerbon.
4. (C is not valid) Assume that the cost of product inventory depends nonlinearly on the number of storing periods and are as follows: storing 1 litre of beer:
* for 1 month: $0.8
* for 2 months: $1
* for 3 months: $1.2

Modify the problem in A and find a solution.

**Problem 2 [To study or to party… That is the question.]**

4 days are left to the final exam and John wants to schedule his work to prepare for the test. John divided each day into an afternoon (2PM-5PM: 3 hours) and an evening (6PM-11PM: 5 hours). It is more difficult to study in the evening, since there is more temptation to go out. A “disutility” of 1 hour of studying at a given period and day is given at a table below:

|  |  |
| --- | --- |
|  | Disutility of 1 hour of studying in a given day and period |
| Day 1 | Day 2 | Day 3 | Day4 |
| afternoon | 1 | 3 | 2 | 7 |
| evening | 2 | 5 | 3 | 10 |

 The following rules have to be obeyed:

* on Day 1 John can study at most 4 hours; each subsequent day John cannot study more than 50% longer than the previous day (not gonna make it)
* on Day 1 each minute of studying means that John actually acquires new material; each subsequent day he wastes 20% of the previous day studying time (just to remind himself what he was studying), the rest is devoted to studying new material – each day the minimal requirement for John is to at least remind himself what he was studying the day before

The exam will take place on Day 5. During the exam John will remember:

* 80% of the new material acquired on Day 4
* 60% of the new material acquired on Day 3
* 50% of the new material acquired on Day 2
* 40% of the new material acquired on Day 1

He needs to remember at least the material equivalent of the 6 hours of studying.

1. Formulate a Linear Programming Problem.

Solve it in Solver.